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मानक

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IS 101-6-5 (1997): Method of sampling and test for paints, varnishes and related products, Part 6: Durability test on Paint films, Section 5: Accelerated weathering test [CHD 20: Paints, Varnishes and Related Products]



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“Knowledge is such a treasure which cannot be stolen”



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भारतीय मानक

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रंग रोगन, वार्निश तथा संबद्ध उत्पादों के नमूने  
लेने और परीक्षण की पद्धतियाँ

भाग 6 रंग रोगन की परतों पर टिकाऊपन परीक्षण

अनुभाग 5 त्वरित अपक्षयन परीक्षण

*Indian Standard*

**METHODS OF SAMPLING AND TEST FOR  
PAINTS, VARNISHES AND RELATED  
PRODUCTS**

**PART 6 DURABILITY TESTS ON PAINT FILMS**

**Section 5 Accelerated Weathering Tests**

ICS 87.040

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**BUREAU OF INDIAN STANDARDS**  
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NEW DELHI 110002

## FOREWORD

This Indian Standard (Part 6/Sec 5) was adopted by the Bureau of Indian Standards, after the draft finalized by the Paints (Other than Industrial Paints) and Allied Products Sectional Committee had been approved by the Chemical Division Council.

The durability of the material is determined by ascertaining actual behaviour of suitably prepared test panels by an accelerated weathering test wherein a prepared panel is subjected to controlled exposure of heat, light and water in the artificial weathering apparatus and evaluating the results of the exposure by a suitable method of rating for various characteristics of the film of the material.

Since the natural environment varies with respect to time, geography and topography. It may be expected that the effects of natural exposure will vary accordingly. All materials are not affected equally by the same environment. Results obtained by using different methods should not be represented as equivalent to those of any natural weathering tests until the degree of quantitative coordination has been established for material under reference.

These days, carbon arc method is not used much by industries and institutions as availability of this equipment and spares has become difficult and as newer and more comprehensive methods are now available. Carbon arc method would be discontinued in course of time and the position will be reviewed after two years.

This standard is one of a series dealing with sampling and testing of paints, varnishes and related products. In the preparation of this standard, considerable assistance has been derived from ASTM 23, 26 and 53.

The composition of technical committee responsible for the formulation of this standard is given in Annex A.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

## *Indian Standard*

# METHODS OF SAMPLING AND TEST FOR PAINTS, VARNISHES AND RELATED PRODUCTS

### PART 6 DURABILITY TESTS ON PAINT FILMS

#### Section 5 Accelerated Weathering Tests

#### 1 SCOPE

This standard (Part 6/Sec 5) prescribes the following three methods for accelerated weathering tests :

- a) Carbon arc,
- b) Xenon arc, and
- c) UV condensation type.

#### 2 REFERENCES

The Indian Standards listed below contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate by dated or undated the possibility of applying the most recent editions of the standards :

<i>IS No.</i>	<i>Title</i>
101	Methods of sampling and test for paints, varnishes and related products:
(Part 1/Sec 3): 1986	Part 1 Test on liquid paints (general and physical), Section 3 Preparation of panels ( <i>third revision</i> )
(Part 6/Sec 1): 1988	Part 6 Durability tests on paint films, Section 1 Resistance to humidity under conditions of condensation ( <i>third revision</i> )
1017 : 1966	Chamois leather ( <i>second revision</i> )

#### 3 PREPARATION OF TEST PANELS

3.1 The panel shall be mild steel plate, 0.8 mm thick and free from surface defects. Panels for the test shall be 150 mm × 75 mm. The panels shall be prepared and cleaned as prescribed in 2 of IS 101 (Part 1/Sec 3) and in 2.2 of IS 101 (Part 6/ Sec 1).

The back and edges of the panels shall be protected with two coats of a suitable paint.

3.1.1 Unless otherwise specified, prior to exposing coated panels in the apparatus, condition them in ambient condition for one of the following periods in accordance with the type of coating:

- |                             |        |
|-----------------------------|--------|
| a) Baked coatings           | 24 h   |
| b) Radiation cured coatings | 24 h   |
| c) All other coatings       | 7 days |

#### 4 CARBON ARC METHOD

##### 4.1 Apparatus

The apparatus employed shall use one carbon arc lamps as the source of radiation and shall be one of the following types. The term cycle is defined as the total time intervals of light and water spray.

##### 4.1.1 Type EH

Single open-flame sunshine carbon arc lamp apparatus, 959 mm diameter specimen rack, automatic control of temperature and cycle with 1 rpm of the specimen rack with automatic control of humidity.

##### 4.1.2 Type HH

Single enclosed carbon arc lamp apparatus, 508 mm diameter specimen rack, automatic control of temperature and cycle with 1 rpm of the specimen rack with automatic control of humidity.

4.1.3 The apparatus shall consist of a suitable frame within which a test chamber and necessary compartments, for housing control and regulating equipment, are located.

4.1.4 Provision shall be made for mounting or supporting the test specimens in a circular rack or drum that is rotated around the arc, providing uniform distribution of the radiation on all specimen.

4.1.5 Adequate ventilation shall be provided in the test chamber to prevent contamination of the specimens from products of combustion of the arc.

4.1.6 The apparatus shall include equipment necessary for measuring and controlling the following:

- a) Arc current
- b) Arc voltage
- c) Black-panel temperature
- d) Water spray pressure
- e) Operating schedule or cycle
- f) Exposure time
- g) Relative humidity

4.1.7 Types EH and HH apparatus are equipped with thermostatically actuated vapourizing units adding moisture to the air as it passes through the conditioning chamber prior to its entry to the test chamber. Relative humidity of the air in the test chamber is calculated from readings of wet and dry-bulb thermometers, either indicating or recording whose sensing part is located in the air stream at the point of exit from the test chamber.

4.1.8 The black-panel thermometer unit shall consist of 1.5 mm stainless steel panel of size 70 mm × 149 mm, mechanically fastened to a stainless steel bimetallic dial type thermometer. This thermometer shall have a stem of 3.99 mm diameter and a dial of 44.4 mm diameter. The sensing portion, extending 38 mm from the end of the stem, shall be located in the centre of the panel, 64 mm from the top and 48 mm from the bottom of the panel. The face of the panel with the thermometer stem attached, shall be finished with two coats of a baked-on black enamel, having resistance to light and water. Control of the black-panel temperature shall be accomplished by thermostatic control of continuous flow of air over the specimen; control of temperature through on-off flow of air in the room, may be permissible.

4.1.8.1 A thermocouple or resistance bulb thermometer mounted at the centre face of the black-panel, which provides temperature values equivalent to the dial thermometer, may be used.

4.1.8.2 Detailed requirements and operating conditions of the apparatus are given in Table 1 and Fig. 1 and Fig. 2.

Table 1 Detailed Requirements and Operating Conditions of Light and Water Exposure Apparatus

Sl No.	Characteristics	Requirement	
		Type EH	Type HH
i)	Line voltage, V	208 to 250	208 to 250
ii)	Arc voltage, V	48 to 52	120 to 145
iii)	Arc current, A	58 to 62	15 to 17
iv)	Carbon electrodes (upper)	Copper coated sunshine <sup>1)</sup>	Neutral cored or solid <sup>2)</sup>
v)	Carbon electrodes (lower)	do	do
vi)	Globe	—	Optical, heat resistant glass <sup>3)</sup> (with cut off at 2 750 Å° and with an increase in transmission to 91 percent at 3 700 Å°).
vii)	Flat panels	Optical, heat resistant glass with light transmission properties similar to Fig. 1. Pyrex brand <sup>4)</sup> (4.5 mm thick) has the following transmission characteristics; 1 percent at 276 nm, 5 percent at 282 nm and 50 percent at 303 nm. Corex brand <sup>5)</sup> (4 mm thick) has the following characteristic; 1 percent at 247 nm, 5 percent at 259 nm and 50 percent at 286 nm.	
viii)	Diameter of specimen drum or rack, mm	959	508
xi)	Speed of rotation of drum	1 rpm	1 rpm
x)	Automatic arc feed	Motor operated	Solenoid operated
xi)	Spray (see figure for arrangement, location and capacity)	Fig. 1	Fig. 2

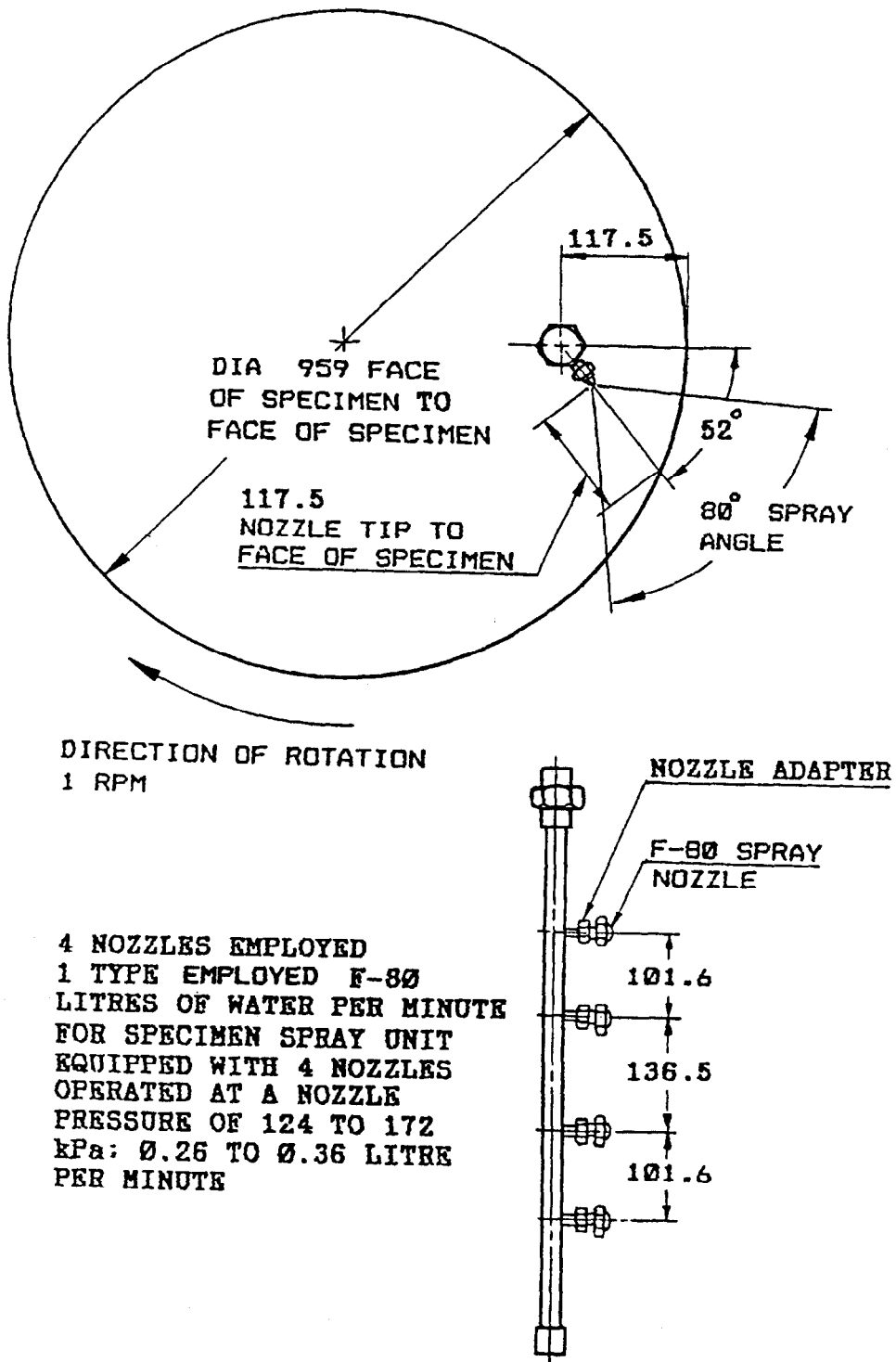
<sup>1)</sup>No. 22 copper coated sunshine carbon electrodes and No. 15.50 copper coated sunshine carbon electrodes or equivalent.

<sup>2)</sup>No. 70 solid carbon electrodes and No. 20 cored electrodes or equivalent.

<sup>3)</sup>No. 9200 Px or equivalent.

<sup>4)</sup>7740 Pyrex filter passes or equivalent.

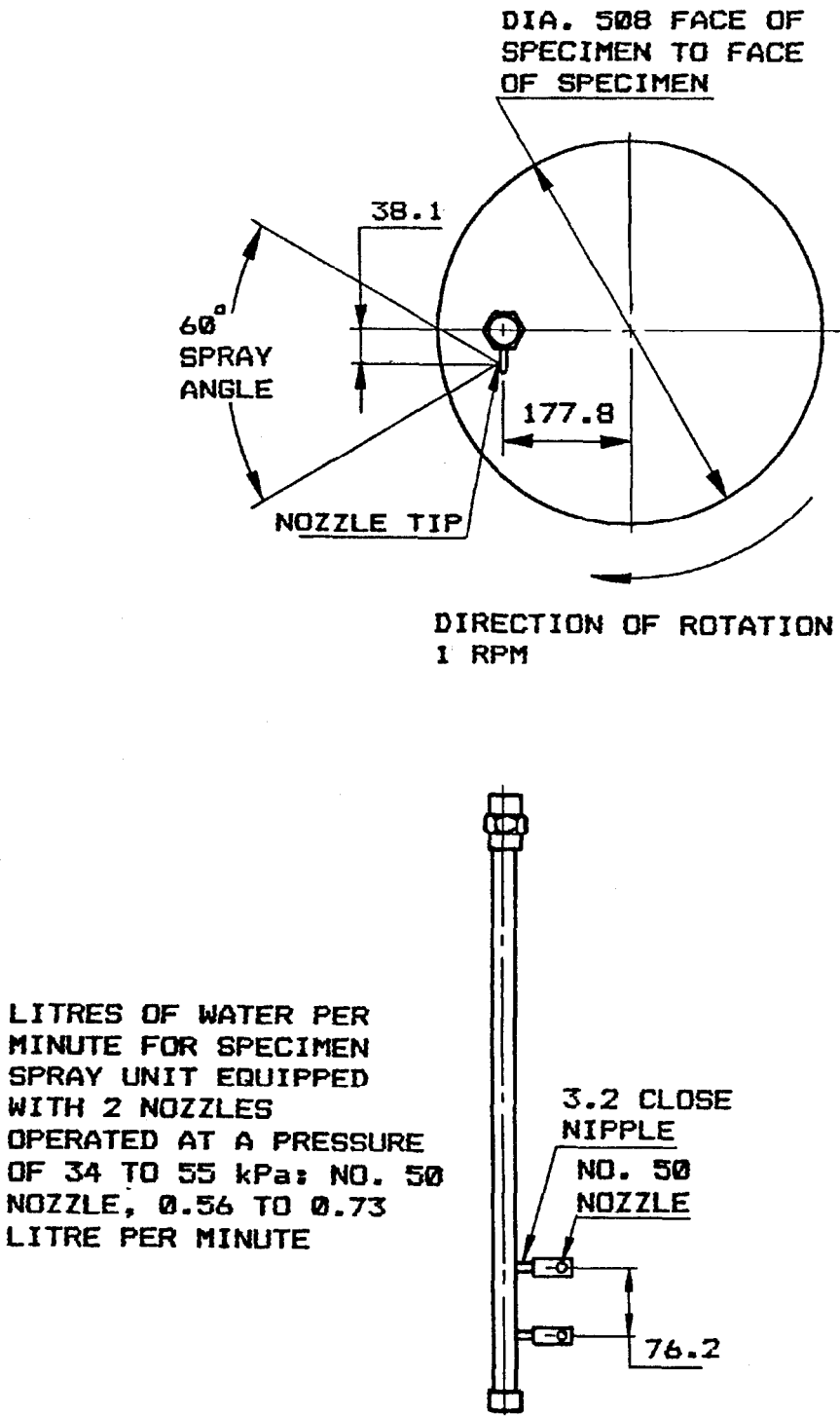
<sup>5)</sup>7058 Corex filter passes or equivalent.



All dimensions in millimetres.

FIG. 1 SPECIMEN SPRAY ARRANGEMENT FOR TYPE E AND EH, SINGLE OPEN — FLAME SUNSHINE CARBON-ARC LAMP APPARATUS





All dimensions in millimetres.

FIG. 2 SPECIMEN SPRAY ARRANGEMENT FOR TYPE H AND HH SINGLE ENCLOSED CARBON-ARC LAMP APPARATUS

## 4.2 Procedure

4.2.1 Prepare specimens in duplicate as prescribed in 3. Mount the test specimen vertically both above and below the horizontal centre line of source of the radiation. To assure uniform total irradiation over the specimen surface, specimens should be repositioned vertically in a sequence which will provide each specimen equivalent exposure period in each location. When the exposure interval does not exceed 24 h, each specimen should be located equidistant from the horizontal axis of the arc.

4.2.2 Temperature measurement and control shall be based on the black-panel thermometer unit. Support the panel with the thermometer attached in the specimen-drum or rack in the same manner as the test specimen, so that it will be subjected to the same influence. Where exterior indicator is not available, read black-panel temperatures through the window in the test chamber-door.

4.2.3 Programme the instrument to operate in a continuous light on mode. Fill specimen-rack with blanks and the black-panel thermometer. Operate in this mode while adjusting dry bulb temperature to provide desired black-panel temperature.

4.2.4 The water from the specimen spray shall strike the specimens in the form of a fine spray equally distributed on the test specimens. Unless otherwise specified the water pressure, number, and type of nozzles shall be in accordance with details as indicated in Fig. 1 or Fig. 2. The water shall have a pH of 6.0 to 8.0 contain less than 20 ppm solids and leave no objectionable deposit or stain on the specimens.

4.2.5 The temperature of the water shall be  $25 \pm 5^\circ\text{C}$  and recirculation of water shall not be permitted unless the recirculated water meets the above requirements. The use of de-ionized or distilled water is advisable.

4.2.6 Replace filters (globe and flat panels) after 2 000 h of use, or when pronounced discolouration or milkiness develops, whichever occurs first. Clean filters each day by washing with detergent (preferably liquid) and water.

4.2.7 Subject the specimens to exposure in duplicate for the period mentioned in product specification or as agreed between the supplier and the purchaser. Operate with automatic control of humidity for 102 min with light followed by 18 min with light with spray, repeating for a total period of 18 h. Follow the 18 h period by 6 h darkness, that is, without light or spray. During the 18 h period light and spray, the black-panel temperature except the specimen spray is on, shall

be  $63 \pm 3^\circ\text{C}$  and the relative humidity of the air shall be  $50 \pm 5$  percent. During the 6 h period of darkness without spray, the black panel temperature shall be  $24 \pm 2^\circ$  and the relative humidity shall be  $95 \pm 4$  percent (Test condition may be changed with mutual consent or required by product specification).

4.2.8 Examine the exposed films at interval of 100 h for following characteristics :

- a) Gloss;
- b) Colour;
- c) Checking, cracking and flaking;
- d) Chalking; and
- e) Spotting.

4.2.9 For the above examinations, wash the right hand half of the surface of the two test panels by pouring water and then wiping with a soft cloth or chamois leather (*see* IS 1017). Adequate time for cooling of the panels to room temperature shall be allowed prior to washing. As an aid in the examination, a magnifying glass may be used, but the evaluation shall be based on an assessment with the unaided eye. At the end of the stipulated period for durability, examine the tested panels against freshly prepared panels not older than 48 h. The sample shall be considered satisfactory if following parameters are satisfactory:

- a) *Gloss retention* — specular gloss retention measured by  $60^\circ$  gloss head;
- b) *Colour retention* — Matching the stipulated shade;
- c) Freedom from checking, cracking, and flaking;
- d) Freedom from chalking;
- e) Freedom from spotting; and
- f) *Freedom from blisters and corrosion* — The film shall remain generally free from blisters and the material underneath shall show no signs of corrosion underneath. One or two localized corrosion and/or rust spots shall not constitute a cause of failure.

## 5 XENON ARC METHOD

5.1 Following four test arrangements have been detailed under this method :

- a) Continuous exposure to light and intermittent exposure to water spray,
- b) Alternate exposure to light and darkness and intermittent exposure to water spray,
- c) Continuous exposure to light without water spray, and
- d) Alternate exposure to light and darkness without water spray.

## 5.2 Apparatus

5.2.1 Two types of apparatus with different exposure conditions are detailed as follows:

- a) Water-cooled type, and
- b) Air-cooled type.

### 5.2.2 Water-Cooled Type

It shall use a water-cooled xenon-arc lamp as the source of radiation and shall be one of the following four general types or their equivalent.

#### 5.2.2.1 Type A

An exposure apparatus in which the source of radiant energy shall be a water-cooled xenon-arc vertically located at the central axis of either a 508 mm diameter vertical specimen rack, or of a 648 mm diameter inclined rack. Means shall be provided for automatic programming of temperature and cycles. Means shall be provided for adjustment of relative humidity. The specimen rack shall rotate at  $1 \pm 0.1$  rpm.

NOTE — In the commercial descriptions of the four types, the term 'cycle' is defined as each time interval of light, darkness, and water spray that is specified differently in accordance with the different testing methods.

#### 5.2.2.2 Type AH

The exposure apparatus shall be identical to Type A except it shall have automatic humidity control.

#### 5.2.2.3 Type B

An exposure apparatus in which the source of radiant energy shall be a water-cooled xenon-arc vertically located at the central axis of a 959 mm diameter specimen rack. Means shall be provided for automatic programming of temperature and cycles. Means may be provided for adjustment of humidity. The specimen rack shall rotate at  $1 \pm 0.1$  rpm.

#### 5.2.2.4 Type BH

The exposure apparatus shall be similar to Type B except it shall have automatic humidity control.

5.2.3 The xenon-arcs employed shall be of the 'long arc' water-cooled type operated through suitable reactance transformers and electrical equipment from a 50 or 60 Hz power supply. They shall employ cylindrical inner and outer optical filters to direct the flow of cooling water and to stimulate a designed spectral energy distribution.

5.2.3.1 For the purpose of this method, the xenon-arc lamp shall consist of a quartz xenon burner tube and one of the following optical filter combinations:

- a) Borosilicate glass inner and outer optical filter to simulate the spectral power distribution (SPD) of natural daylight throughout the actinic region.

- b) Infrared absorbing glass inner optical filter with quartz outer optical filter to simulate the SPD of natural daylight (300 nm to 1 000 nm).
- c) Borosilicate glass inner optical filter with soda lime glass outer optical filter to simulate the SPD of natural daylight (actinic wavelengths) filtered through window glass.
- d) Infrared absorbing glass inner and outer optical filter to simulate the SPD of natural daylight (310 nm to 1 000 nm).
- e) Quartz inner and outer optical filter to approximate sunlight intensities unfiltered by the earth's atmosphere.

5.2.3.2 To prevent loss in levels of irradiance due to excessive solarization and to prevent possible breakage caused by stresses in optical filter exposed to high-intensity UV energy, inner optical filters shall be replaced periodically, preferably after 300 h and 400 h for Types A and B, respectively. The outer optical filter shall be replaced after 1 500 h and 2 000 h for Types A and B, respectively.

5.2.4 Distilled or de-ionized water shall be recirculated past the burner at a flow rate sufficient to remove excess heat. Passing water through a cartridge de-mineralizer installed in the recirculation line just ahead of the lamp, minimize contamination of the quartz envelope of the burner. A heat-exchange unit shall be used to cool the recirculated lamp water.

5.2.5 Since xenon-arc lamps, like all gas discharge lamps have a progressive drop in radiation output with continued use, and since optical filters changes in their transmission characteristics, provision shall be made in the apparatus (automatically or manually) for progressively increasing the wattage of the lamp to minimize changes in the intensity of the radiation at the face of the sample. The greatest change in both the xenon burner tube and optical filters occurs in the first 20 h of use. For this reason, burners and optical filters pre-aged by the instrument manufacturer are recommended for critical testing when a more rapidly changing rate of intensity is undesirable. For routine testing on a comparative basis, the 20 h of pre-aging may be omitted.

5.2.6 Many non-metallic materials are selectively absorbing. The energy that a molecule absorbs depends upon the wavelength of the incident radiation. It is desirable to monitor the level of irradiance of the photochemically effective wavelengths if intercomparisons are to be made among samples not exposed simultaneously. Samples may then be exposed to known amounts of irradiating, the time integral of irradiance.

**5.2.6.1** Where radiometers capable of monitoring discrete portions of a continuous spectrum are available, exposure to a mutually agreed-upon level of irradiation may be specified as the exposure interval in place of a time interval.

- a) When using the optical filter combination described in 5.2.3.1 (a), the suggested minimum spectral irradiance levels are:
- 0.2 W/m<sup>2</sup> nm band at 320 nm
  - 0.35 W/m<sup>2</sup> nm band at 340 nm
  - 0.5 W/m<sup>2</sup> nm band at 380 nm
  - 0.75 W/m<sup>2</sup> nm band at 420 nm
- b) When using the optical filter combination described in 5.2.3.1(c), the suggested minimum spectral irradiance levels are:
- 0.2 W/m<sup>2</sup> nm band at 340 nm
  - 0.45 W/m<sup>2</sup> nm band at 380 nm
  - 0.7 W/m<sup>2</sup> nm band at 420 nm
- c) Operating at the suggested minimum levels approximates the average daily solar irradiance under ideal conditions. It is about half of the maximum values for total irradiance on a horizontal plane when the sun is at 90° altitude. When irradiance is monitored and periodic manual adjustment of wattage is made to compensate for changes of intensity, no lamp assembly shall be used that cannot maintain the minimum level of irradiance within a 10 percent tolerance at the monitored wavelength. Irradiation expressed as joules per square metre is the product of irradiance and exposure time in seconds.

**5.2.6.2** Xenon-arc type equipment not having a radiometer shall be operated with periodic increase in wattage to minimize any drift in levels of irradiation. Such intervals shall be established by mutual agreement or follow the suggested schedule given below at (a).

NOTE — The use of suggested wattage steps does not imply that irradiance will be maintained at levels equivalent to those obtained when employing a light monitor. These are intended as a guide to minimize the reduction of UV intensity with maximum lamp longevity when using either test method (a), (b) or (c) for 2.5, 6 or 6.5 kW lamps, respectively.

- a) The following are the suggested wattage settings for each exposure interval of a 2 500 W xenon burner tube based upon the average performance of xenon burner tubes with borosilicate filters :

<i>Time, h</i>	<i>Power, W</i>
0 to 20	1 600
20 to 200	1 800
200 to 400	2 000
400 to 600	2 250
600 to 800	2 500
800 to 1 000	2 600

1 000 to 1 200	2 800
1 200 to 1 500	3 000

- b) The following are the suggested wattage settings for each exposure interval of a 6 000 W xenon burner tube based upon the performance of xenon burner tubes with borosilicate filters in test method (a) :

<i>Time, h</i>	<i>Power, W</i>
0 to 20	<i>Min</i>
20 to 100	4 750
100 to 250	5 000
250 to 400	5 250
400 to 550	5 500
550 to 700	6 000
700 to 850	6 500
850 to 1 000	7 000

- c) The following are the suggested wattage settings for each exposure interval of a 6 500 W xenon burner tube based upon the average performance of xenon burner tubes with borosilicate filters :

<i>Time, h</i>	<i>Power, W</i>
0 to 20	<i>Min</i>
20 to 100	5 500
100 to 200	6 000
200 to 500	6 200
500 to 1 000	6 500
1 000 to 1 500	7 000
1 500 to 2 000	7 500
2 000 and over	8 500

**5.2.7** Specimens shall be mounted on a rack rotating about the lamp at a distance such that the location of each specimen assures that the irradiance incident on its surface does not vary by more than 5 percent from the average.

**5.2.8** Any apparatus that does not comply with the condition of 5.2.7 shall not have a variation in irradiance exceeding 10 percent of the average and may require specimen rearrangement during exposure in accordance with the test procedure in order to minimize the variability in radiant exposure.

**5.2.9** Testing temperatures shall be measured and regulated on the basis of a black-panel thermometer unit mounted on the specimen rack so that the face of the unit is in the same relative position and is subjected to the same influences as the test specimens. The black-panel thermometer unit shall consist of a stainless steel panel about 75 mm × 50 mm × 0.95 mm to which a stainless steel bimetallic dial-type thermometer is mechanically fastened. This thermometer shall have a stem approximately 4 mm in diameter with a 44.5 mm dial. The sensitive portion extending about 38 mm from the end of the stem shall be located in the centre of the panel approximately 64 mm from the

top and approximately 48 mm from the bottom of the panel. The face of the panel with the thermometer stem attached shall be finished with a baked-on black infrared-absorbing coating having good resistance to light.

5.2.9.1 A thermocouple or resistance bulb thermometer mounted at the centre face of the black panel which provides temperature values equivalent to the dial thermometer may be substituted.

5.2.10 A blower unit in the base of the apparatus shall provide a flow of air through the test chamber and over the test specimens. Control of specimen and black panel temperature shall be accomplished by thermostatic control of the temperature of the constant volume of air from the blower. Black-panel temperatures shall be read through the window in the test chamber-door without opening the door.

5.2.11 Apparatus operated as a light-and water-exposure test shall be equipped with a specimen spray until as illustrated in Figs. 3 and 4. All components of the specimen spray unit should be fabricated from stainless steel, plastic, or other material that does not contaminate the water. Apparatus operated only as a light-exposure test are not required to have the specimen spray unit or, if present, it shall not be used.

5.2.12 Types A, AH, BH and some Type B apparatus are equipped with an electrically operated vapourizing unit for adding moisture to the air as it passes through the conditioning chamber in the base section prior to its entry into the test chamber of the apparatus.

5.2.12.1 In Types A and B the vapourizing unit when manually turned on, may operate continuously while the apparatus is in operation. Type A and some Type B apparatus may be programmed to operate the vapourizer during a dark cycle only. The temperature of the water, with which the vapourizer is supplied, is not controlled. In Type B apparatus not supplied with a vapourizing unit, the relative humidity within the test chamber is, governed by evaporation of water in the bottom of the chamber and from water emitted through the specimen spray unit.

5.2.12.2 Types AH and BH apparatus, operation of the vapourizer is controlled automatically by a wet-bulb thermostat. The temperature of the water supplied to the vapourizer is regulated automatically by thermostatically — actuated electric immersion heaters. Control automatically shifts between two separate sets of thermostats as the arc lamp is turned on and off by the programme control unit.

5.2.13 In Types A, B, AH and BH apparatus containing vapourizing units, relative humidity is determined from wet and dry-bulb thermometers located in the air stream at the vapourizer's point of exit from the test chamber.

5.2.13.1 Determine the relative humidity for Type B apparatus not equipped with a vapourizing unit from wet and dry-bulb thermometers mounted in holders on the specimen rack so that their sensitive portions are in the same relative position as the face of the test specimen but shielded from the radiation.

5.2.13.2 Any apparatus with a vapourizing unit operated with the unit and immersion heaters turned off will provide essentially the same conditions of relative humidity as are produced in Type B apparatus without a vapourizing unit.

5.2.14 The apparatus shall include means for measuring the following:

- a) Wattage of the xenon-arc lamp;
- b) Irradiance at the specimen rack;
- c) Black-panel temperature;
- d) Dry-bulb temperature (test chamber);
- e) Wet-bulb temperature (test chamber);
- f) Exposure interval; and
- g) Water spray pressure when applicable.

5.2.15 Where specified, the apparatus shall include means for regulating or controlling the following:

- a) Wattage of the xenon lamp;
- b) Irradiance or irradiation, or both, at the specimen rack;
- c) Temperature (test chamber);
- d) Relative humidity (test chamber);
- e) Light-dark-spray-humidity-temperature cycles; and
- f) Water spray pressure when applicable.

#### 5.2.16 *Air-Cooled Type*

The apparatus employed shall use an air-cooled xenon-arc lamp as the source of radiation and shall be one of the following types or their equivalent.

##### 5.2.16.1 *Type C*

Air-cooled xenon-arc apparatus, 1 500 W, 158 mm diameter specimen rack, with automatic programming of cycles and humidity. The specimen rack shall rotate at  $5.2 \pm 0.1$  rpm.

##### 5.2.16.2 *Type D*

Air-cooled xenon-arc apparatus, 4 500 W, 360 mm diameter specimen rack, with automatic programming of temperature, cycles and humidity. The specimen rack shall rotate at  $3.7 \pm 0.1$  rpm.

### 5.2.16.3 Type E

Air-cooled xenon-arc apparatus, three lamps operating simultaneously at 4 500 W each, 610 mm diameter specimen rack, with automatic programming of temperature, cycles and humidity. The specimen rack shall rotate at  $2.0 \pm 0.1$  rpm.

5.2.17 The xenon-arcs employed in Types C and D shall be of the medium-pressure, air-cooled type and one or more optical filters shall be fitted between the light source and the samples to filter out undesired wavelengths of radiation. A combination of optical filters recommended by the manufacturer shall be used to simulate: (a) sunlight in the open, (b) sunlight behind window glass, or (c) any other simulated solar irradiation condition desired.

5.2.18 All gas discharge lamps have a progressive drop in radiant output with continued use. For Types C and D, it is recommended to exchange the IR-optical filters for new ones after 3 500 h of use. Answering the purpose, not all seven IR-optical filters of the filter lantern shall be exchanged at the same time but each shall be exchanged after it has run for 3 500 h. For Type E which has three lamps, one lamp shall be replaced every 500 h to minimize the overall drop in radiant output. For Type E, the three partial pre-aged filters shall be cleaned monthly and replaced after five years of normal usage.

5.2.19 Specimen holders shall rotate around the arc, describing a cylindrical surface, so that specimens may face, or be turned opposite to the arc. No part of the specimens shall be above or below the ends of the arc. Repositioning of specimens in upper, centre, or lower positions can improve the uniformity of intensity of the exposure.

5.2.20 Testing temperatures shall be measured and regulated on the basis of a black-panel thermometer unit that is mounted so that the face of the unit is in the same relative position and is subjected to the same influences as the test specimens. The black-panel thermometer unit shall consist of a stainless steel panel approximately 48 mm  $\times$  200 mm  $\times$  1 mm, to which a stainless steel bi-metallic dial-type thermometer is mechanically fastened. The temperature at the centre of the panel shall be sensed by the thermometer. The face of the panel shall be finished with a baked-on black glossy enamel having good stability to light.

5.2.21 A blower unit in the base of the apparatus shall provide a flow of air through the test chamber and over the test specimens. Control of the specimen and the black-panel temperature shall be accomplished by thermostatic control of the

temperature of the constant volume of air from the blower. Black-panel temperature shall be read through the window in the test chamber-door without opening the door.

5.2.22 The apparatus shall be equipped with a system to spray the specimens uniformly with water. This system shall be of stainless steel, plastic, or other material that does not react with or contaminate the water employed.

5.2.23 Relative humidity in the test chamber shall be measured and controlled by a contact hygrometer. Water shall be vapourized and diffused to enrich the air with moisture and produce the required humidity.

5.2.24 The apparatus shall include equipment necessary for measuring and controlling the same parameters as listed for water-cooled xenon-arcs.

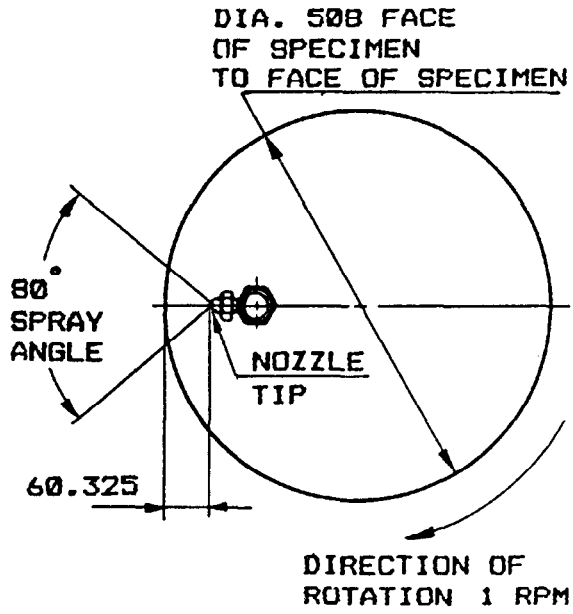
## 5.3 General Procedure

5.3.1 Check to be sure the apparatus is operating properly at the start of each test. Check the lamp operation at 100 h intervals to ensure that burner tube and optical filters are clean and that these have not exceeded the maximum recommended period of use.

5.3.2 Programme the instrument to operate in the continuous light-on mode without water spray. Fill the specimen rack with blanks and the black-panel thermometer. Operate the instrument in this mode while regulating the chamber dry-bulb temperature to provide the desired black-panel temperature of  $63 \pm 3^\circ\text{C}$ .

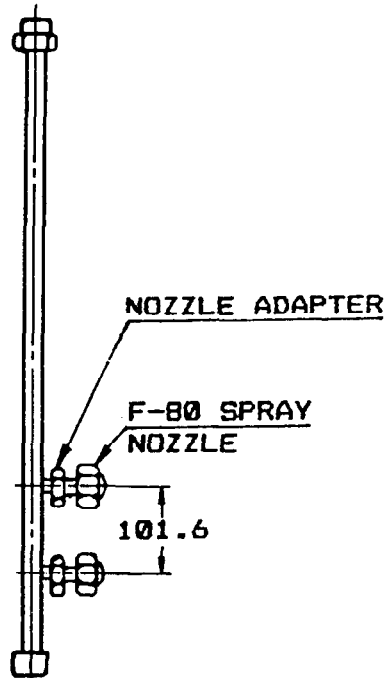
5.3.3 When the chamber dry-bulb temperature has been regulated, adjust instruments with automatic humidity control to the desired relative humidity (Types C, D and E) or to the chamber wet-bulb temperature (Types A and B) at the level that will ensure the desired relative humidity.

5.3.4 In Types A, B, C, D and E apparatus, use the types and number of spray nozzles (see Fig. 3 and Fig. 4) recommended by the manufacturer and operate at a pressure of 124-172 kPa measured at the nozzle unless otherwise recommended. The water shall have a pH of 6.0 to 8.0, contain less than 20 ppm solids, and leave no deposit or stain in the specimens after continued exposure in the apparatus. The temperature of the water shall be  $16 \pm 5^\circ\text{C}$  and recirculation of the water shall not be permitted unless the recirculated water meets the above requirements. Pass the specimens through the spray once in each minute or revolution of the rack during the spray cycle. Allow the water to strike the test specimens in the form of a fine spray equally distributed over the specimens.



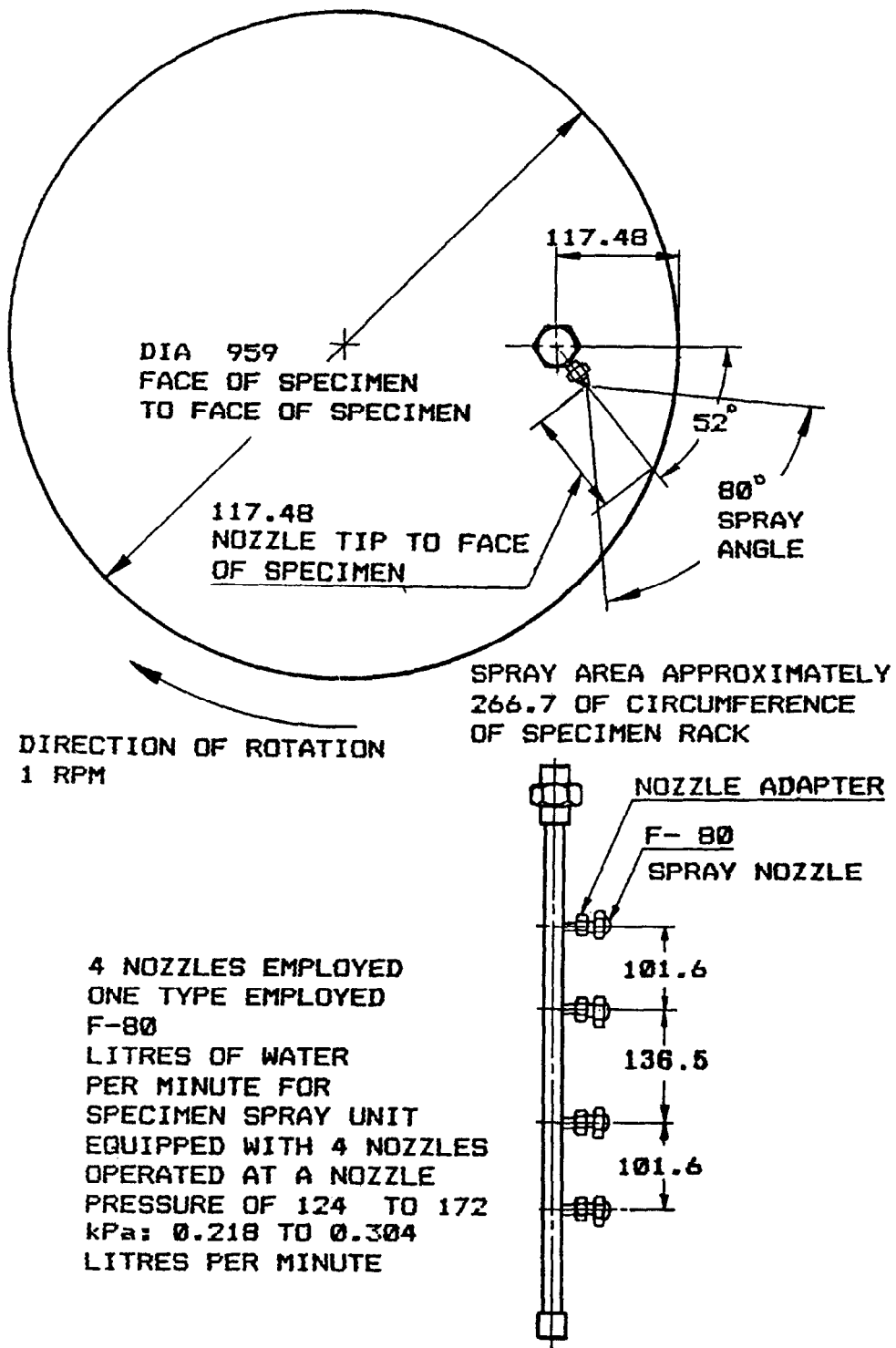
SPRAY AREA APPROXIMATELY 101.6 OF CIRCUMFERENCE OF SECIMEN RACK

LITRES OF WATER PER MINUTE FOR SPECIMEN SPRAY UNIT EQUIPPED WITH 2 NOZZLES OPERATED AT A PRESSURE OF 124 TO 172 kPa: F-80 NOZZLE. 0.109 TO 0.152 LITRE PER MINUTE



All dimensions in millimetres.

FIG. 3 SPECIMEN SPRAY ARRANGEMENT FOR TYPE A AND AH APPARATUS



All dimensions in millimetres.

FIG. 4 SPECIMEN SPRAY ARRANGEMENT FOR TYPE B AND BH APPARATUS



**5.3.5** The temperature of the rack spray water shall be sufficiently low to reduce the specimen temperature below the dewpoint when the specimen is continuously sprayed during a dark cycle.

#### **5.3.6 Reference Standard**

**5.3.6.1** Any standard sample established by mutual agreement between the purchaser and the supplier.

#### **5.3.6.2 ISO gray scale for assessing change in colour**

When the material to be evaluated is suspected to be very sensitive to variations in radiant exposure and the apparatus does not meet the requirement of 5.2.7, it is the responsibility of the concerned parties to mutually agree upon a rearrangement schedule for specimens as part of the exposure programme in order to minimize any effect that variations in irradiance might have with respect to specimen position.

### **5.4 Procedure**

For arrangements detailed at 5.1(a).

**5.4.1** Apparatus shall be Type A, B, AH, BH, C, D or E light-exposure device.

**5.4.2** Programme the instrument for continuous light and intermittent water spray in accordance with the manufacturer's instructions. Choice of the programme selected shall be by mutual agreement among the interested parties. A cycle of 102 min of light followed by a cycle of 18 min of light and water spray as a commonly accepted programme that permits the attainment of the maximum black-panel temperature during the light-only portion of the cycle.

**5.4.3** In Types AH and BH apparatus, adjust dry- and wet-bulb temperature controls, humidifier and immersion heater controls to maintain the desired conditions as specified in 4. In Types C, D and E adjust the chamber temperature and humidity controls to maintain desired conditions as specified in 5.3.

**5.4.4** In Types A and B with humidifier, humidity may be adjusted but not controlled.

**5.4.4.1** Type B instrument without a humidifier shall operate with whatever humidity occurs from the evaporation of water in the bottom of the test chamber and from specimen spray.

### **5.5 Procedure**

For arrangements detailed at 5.1(b).

**5.5.1** Apparatus shall be Types A, B, AH, BH or E light exposure device.

**5.5.1.1** Types AH, BH and E apparatus with automatic humidity controls shall be operated on alternate light and dark cycles. Types C, D and E shall be operated with 180° specimen rotation per revolution about the lamp.

a) Operation during the light-on cycle shall be as described in 5.4.

b) Separate controls for temperatures and humidification shall be adjusted during the dark cycle for automatic control as the programme alternates from light to dark. In Types BH and E apparatus, a rack spray to cool the specimens by wetting the unexposed back surface may result in development of condensation on the exposed specimen surface during the dark cycle.

**5.5.1.2** Types A, B, AH, BH and E shall be programmed to operate on alternate light and dark cycles without control of relative humidity.

### **5.6 Procedure**

For continuous exposure to light without water spray.

**5.6.1** Apparatus shall be Types A, B, AH, BH, C, D or E light-exposure devices programmed for continuous light only, in accordance with the manufacturer's instructions. Optical filters described in 5.2.3.1 (c) or (d) shall be used.

**5.6.1.1** Adjust the controls on the apparatus so that the black-panel temperature is  $63 \pm 3^\circ\text{C}$  and the relative humidity is  $30 \pm 5$  percent. Check at regular intervals and when necessary, readjust the controls to maintain the specified values for these variables.

**5.6.1.2** Expose the material to be tested as determined by mutual agreement among the concerned parties or, when not otherwise specified, in accordance with the following:

Expose the test specimen and any mutually agreed-upon standard sample until either, by any specified or mutually agreed-upon method of measurement, shows an agreed-upon method of measurement, shows an agreed-upon amount of change. Report the results on the basis of a comparison of the specimen with the standard sample.

### **5.7 Procedure**

For alternate exposure to light and darkness without water spray.

**5.7.1** Apparatus shall be Types A, B, AH, BH or E programmed to predetermined cycles of light and darkness by turning off the xenon-arc, or apparatus shall be Types C, D and E programmed for light and dark cycles by rotating the exposed face of the

specimen 180° away from the arc. The method will be determined by the apparatus used and results may not be comparable between the two.

NOTE — Type B instruments not equipped with a vapourizing unit do not meet the requirements of this test. In Type A and Type B apparatus with intermittent blower operation during the light-off cycle and the atomizer in continuous operation, the test chamber air temperature will drop to that of room air less the heat removed by vapourization of water from wicks and atomizer.

**5.7.1.1** Unless otherwise specified, exposure conditions shall be identical to those given in 5 except that during the light-on cycle, the equilibrium condition or relative humidity shall be  $35 \pm 5$  percent and during periods of darkness, equilibrium condition shall be  $90 \pm 5$  percent relative humidity at a dry-bulb temperature of  $35 \pm 3^\circ\text{C}$ .

NOTE — When direct measurement of irradiation and spectral irradiance cannot be made, data supplied by the manufacturer shall be substituted. Irradiation in kilo Joules per square metre ( $\text{kJ/m}^2$ ) may be calculated by multiplying the product of the irradiance in watts per square metre ( $\text{W/m}^2$ ) and the exposure time in hours by a factor of 3.6.

## 6 UV CONDENSATION TYPE METHOD

### 6.1 Apparatus

#### 6.1.1 Test Chamber

Constructed of corrosion-resistant materials enclosing eight fluorescent UV lamps, mounted in two banks of four lamps each, a heated water pan, test specimen racks, and provisions for controlling and indicating operating times and temperatures (see Fig. 5).

#### 6.1.2 Lamps

Rapid start, medium bipin fluorescent UV lamps with a length of 1 220 mm, and a nominal rating of 40 W when operated from a ballast providing a controlled current of 430 mA at 102 V.

**6.1.2.1** Unless otherwise specified, the lamps shall be UV-B lamps with a peak emission at 313 nm and a spectral energy distribution as shown in Fig. 6.

### 6.2 Specimen Mounting and Arrangement

The test specimens shall be mounted in stationary racks with the plane of the test surface parallel to the plane of the lamps at a distance of 50 mm from the nearest surface of the lamps, as shown in Fig. 5.

**6.2.1** The test specimens shall be exposed within an area 210 mm in height by 900 mm wide on each side of the apparatus.

### 6.3 Condensation Mechanism

Water vapour shall be generated by heating a water pan extending under the entire sample area and containing a minimum water depth of 25 mm. Specimen racks and the test specimens themselves shall constitute the side walls of the chamber. The back side of the specimens shall be exposed to cooling effects of ambient room air. The resulting heat transfer causes water to condense on the test surface.

**6.3.1** The specimens shall be arranged so that condensate runs off the test surface by gravity and is replaced by fresh condensate in a continuous process. Vents along the bottom of the test chamber shall be provided to permit an exchange of ambient air and water vapour to prevent oxygen depletion of the condensate.

### 6.4 Water Supply

It shall be provided with an automatic control to regulate the level in the water pan. Distilled, de-ionized, or potable tap water are equally acceptable for purposes of the test, since the condensation process itself distills water onto the test surface.

### 6.5 Cycle Timer

A continuously operating cycle time, for programming the selected cycle of UV periods and condensation periods. Hour-meters shall be provided to record total time of operation and total time of UV exposure.

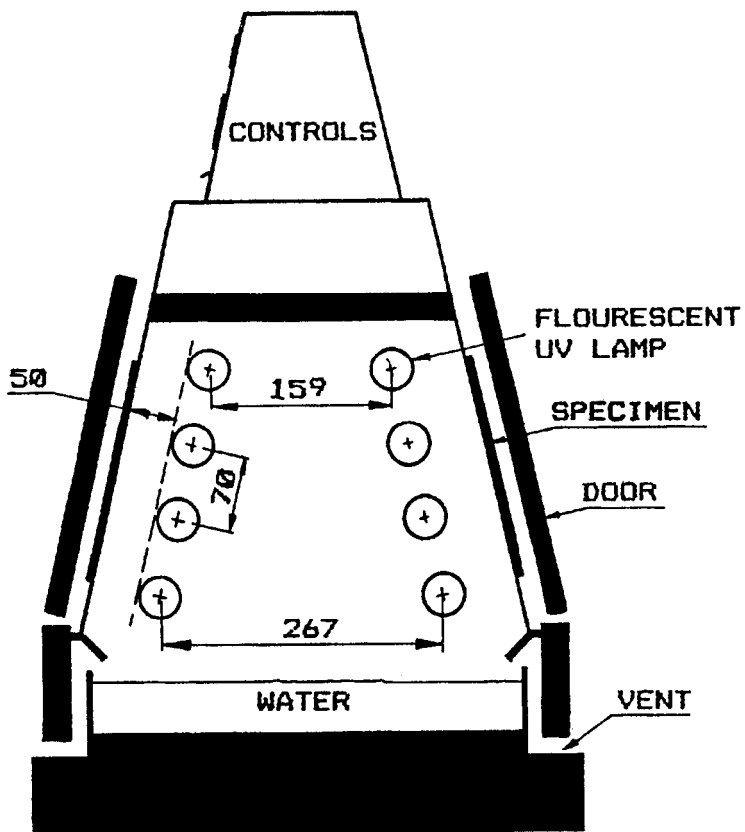
### 6.6 Specimen Temperature Measurement

Specimen temperature shall be measured by a thermometer with a remote sensor attached to a black aluminium panel 75 mm × 100 mm × 2.5 mm. The thermometer shall be precise to  $\pm 1^\circ\text{C}$  through a range from 30° to 80°C. The indicator dial shall be located outside the test chamber.

**6.6.1** The black aluminium panel with the thermometer sensor shall be positioned in the centre of the exposure area so that the sensor is subject to the same conditions as the specimens.

### 6.7 Test Chamber Location

**6.7.1** The apparatus shall be located in an area maintained at a temperature between 20°C and 30°C. The room temperature shall be measured by thermometers mounted on interior walls or column approximately 1 500 mm above the floor level and at least 300 mm from any heated apparatus. Three or more thermometers located at various points will show any temperature variation in the area.



All dimensions in millimetres.

FIG. 5 APPARATUS SCHEMATIC CROSS SECTION

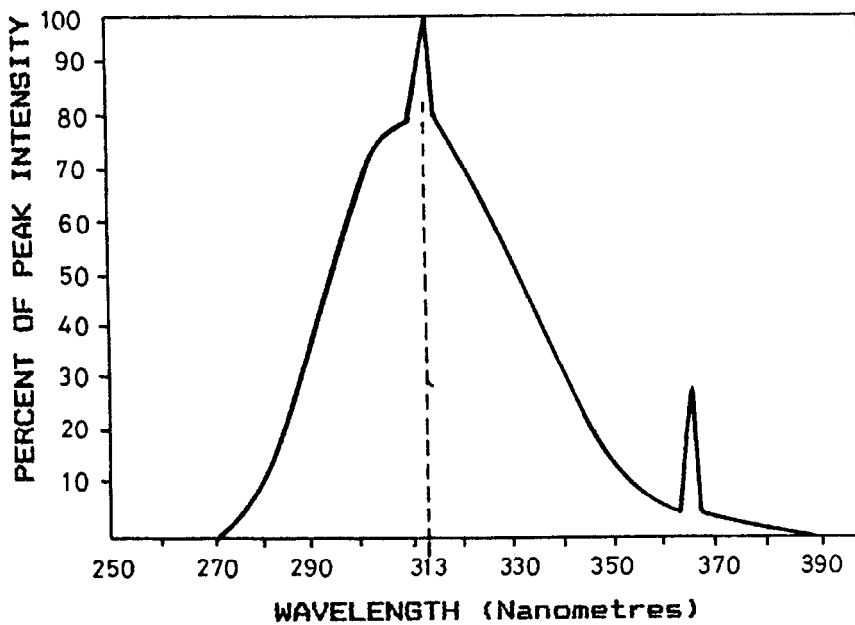


FIG. 6 TYPICAL RELATIVE SED OF UV-B LAMP

6.7.2 It is recommended that the apparatus be located at least 300 mm from walls or other apparatus. Nearby heat sources, such as ovens or heated test apparatus, may be avoided or shielded, because such heat sources may reduce the cooling required for condensation.

6.7.3 The room where the apparatus is located shall be ventilated to remove the heat and moisture produced and to maintain the temperatures specified in 6.7.1. Two to four air changes per hour will normally provide sufficient ventilation.

## 6.8 Procedure

6.8.1 Mount the test specimens in the specimen racks with the test surfaces facing the lamp. When the test specimens do not completely fill the racks, fill the empty spaces with blank-panels to maintain the test conditions within the chamber.

6.8.2 Various test conditions may be used. If no temperatures are suggested : 4 h UV at 60°C, 4 h condensation at 50°C. Operate continuously, repeating the cycle, except for servicing the instrument and inspection of specimens.

NOTE — The time cycles widely used are 4 h UV/4 h condensation, and 8 h UV/4 h condensation. Use UV and condensation periods of at least 2 h duration to allow sufficient time to reach equilibrium.

## 6.8.3 Maintenance

Periodic maintenance is required to maintain uniform UV and condensation exposure conditions.

6.8.3.1 After 400 to 450 h of lamp operating time, replace one lamp in each bank of lamps, and rotate the other lamps as shown in Fig. 7. The procedure provides a useful lamp life of 1 600 h to 1 800 h.

6.8.3.2 Drain water and clean water pan when conducting lamp replacement and rotation procedure. Scum on the top of the water, may inhibit water vapourization.

6.8.4 Inspect specimens daily in tests with a length of 1 week or less. Tests for longer periods may be inspected weekly. In order to minimize any effects from temperature or UV light variation, samples may be repositioned on a regular schedule.

6.8.4.1 A permanent record of degradation at various times may be obtained by using three replicate specimens and removing the replicates sequentially at intervals equal to one-third of the test length. Conclude the test when total test hours have been consumed in testing.

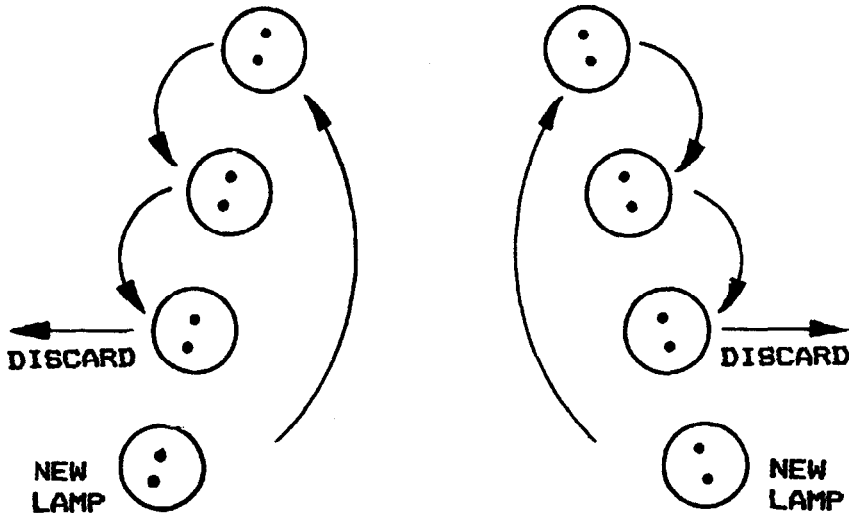


FIG. 7 LAMP ROTATION

**ANNEX A**  
*(Foreword)*  
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*(Continued on page 17)*

( Continued from page 16 )

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### Amendments Issued Since Publication

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